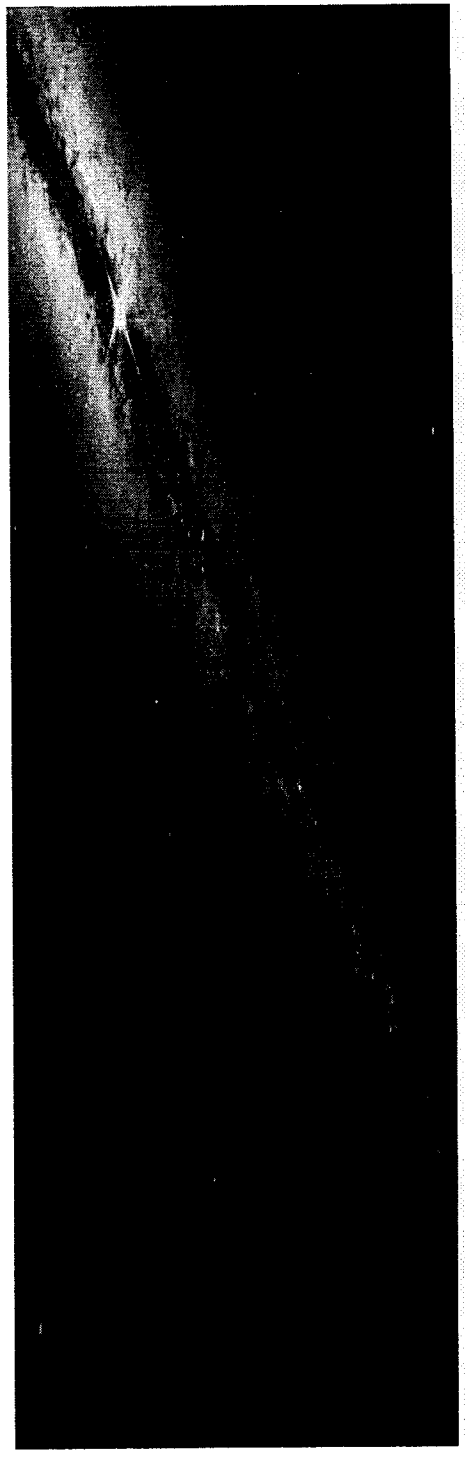

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Mars Image Processing on Commodity Clusters

Science Data Processing Session

Myche McAuley,

Gerhard Klimeck, Bob Deen, Gary Yagi, Tom Cwik, Eric De Jong

Jet Propulsion Laboratory, California Institute of Technology

Multimission Image Processing Lab

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Mars Image Processing on Clusters

Need

- Mosaics and terrain data from sequences of images.
- Rapid turnaround for the rover navigation team in operations.

Problem

- Current technology requires about 90 minutes per mosaic and 70 minutes per correlation pair.
- Requirements are 30 minutes for 2.5x larger datasets.

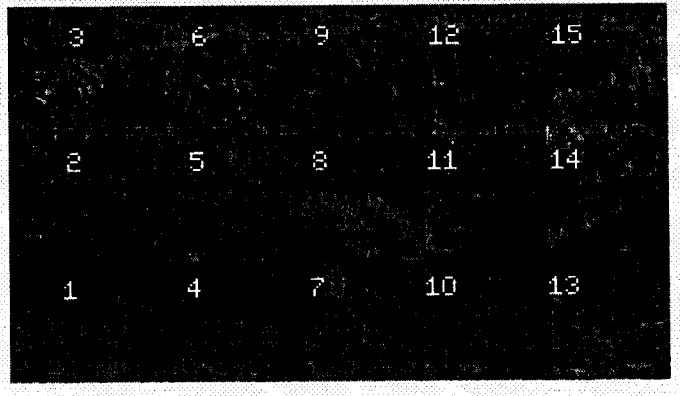
Approach

- Parallelize on a commodity cluster.

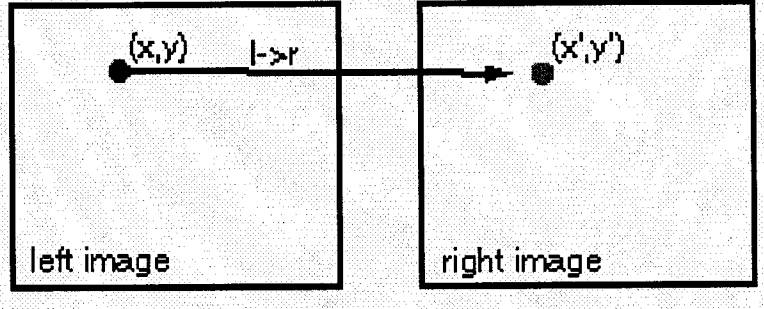
Outline of Presentation

- Reduction of mosaic times.
- Reduction of correlation times.
- Enable correlation quality control.
- Increase correlation algorithm stability.

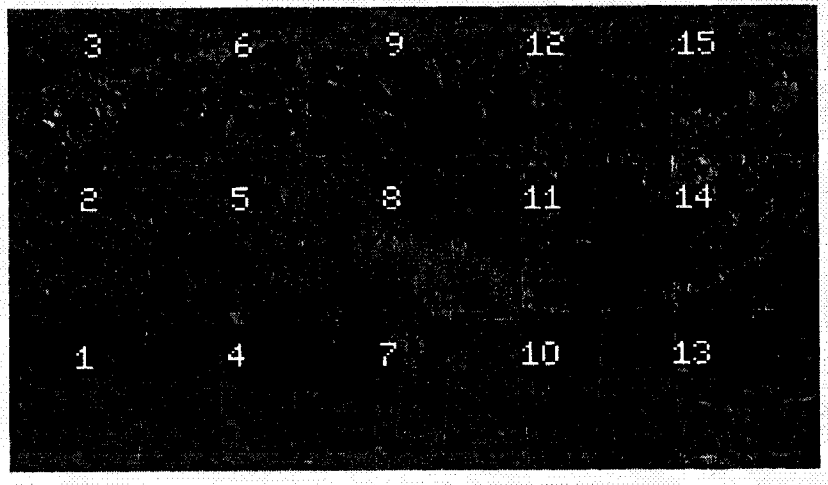
Mosaics from many images



Correlation of Stereo Pairs



Mars Mosaic Images

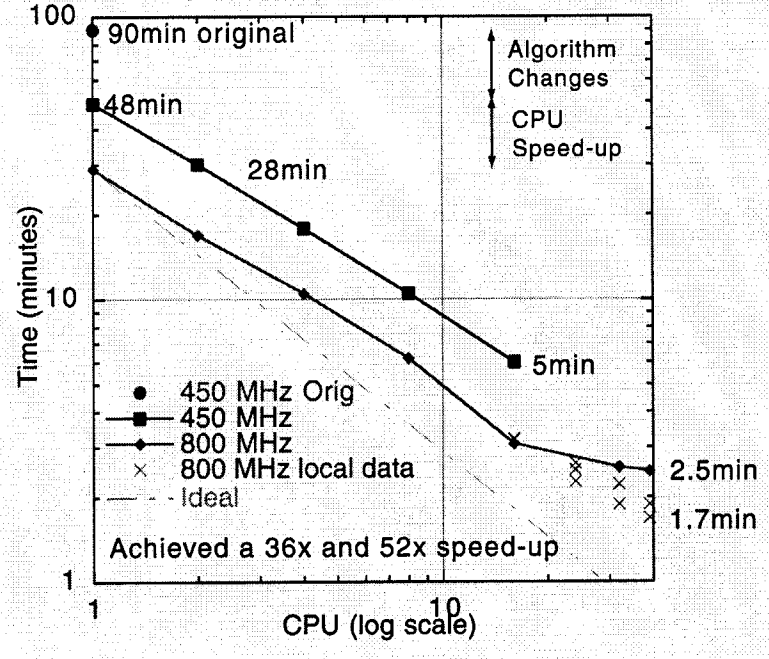


Problem:

- Need to stitch together one single image from hundreds of individual images
- Software exists, but but takes 90minutes to assemble one image from 120 images.

Approach:

- Optimize existing algorithm.
- Parallelize existing software
  - Subdivide image into slices 1 slice/CPU



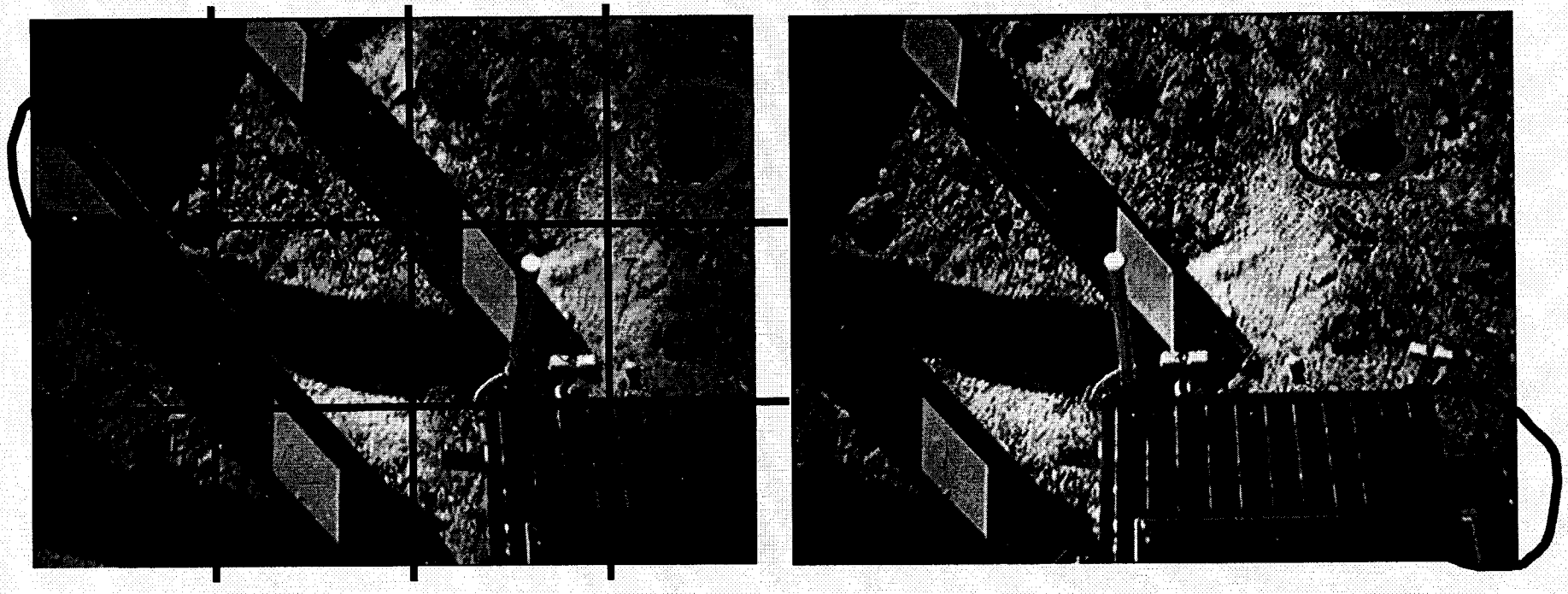
Results:

- Starting point 450MHz: 90 minutes
- Algorithm Changes -
  Storage of all images: 48 minutes
- 16 CPUs / 450MHz: 5 minutes
- 40 CPUs / 800MHz: 2.5 minutes
- with local data:
  40 CPUs / 800MHz: 1.7 minutes /

Impact:

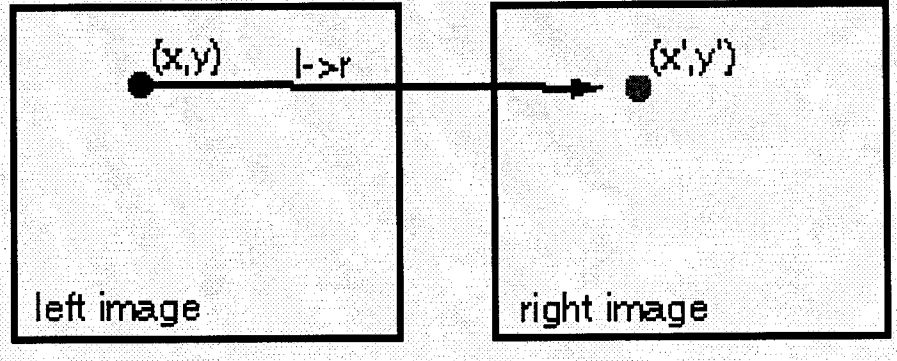
- Near real-time processing of mosaics.
- Software part of the processing pipeline

Left & Right Stereo Image Correlation

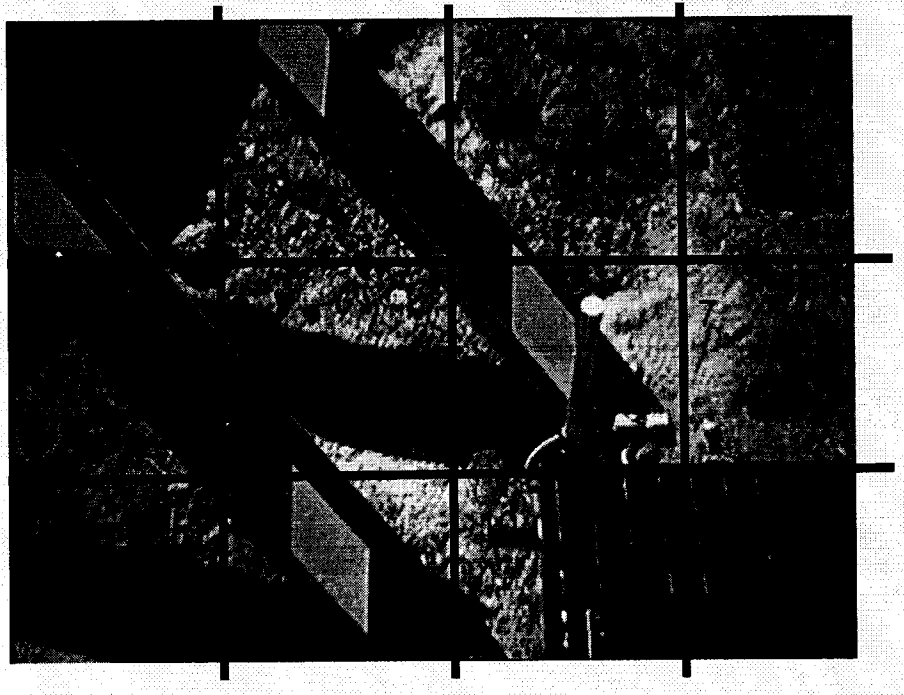


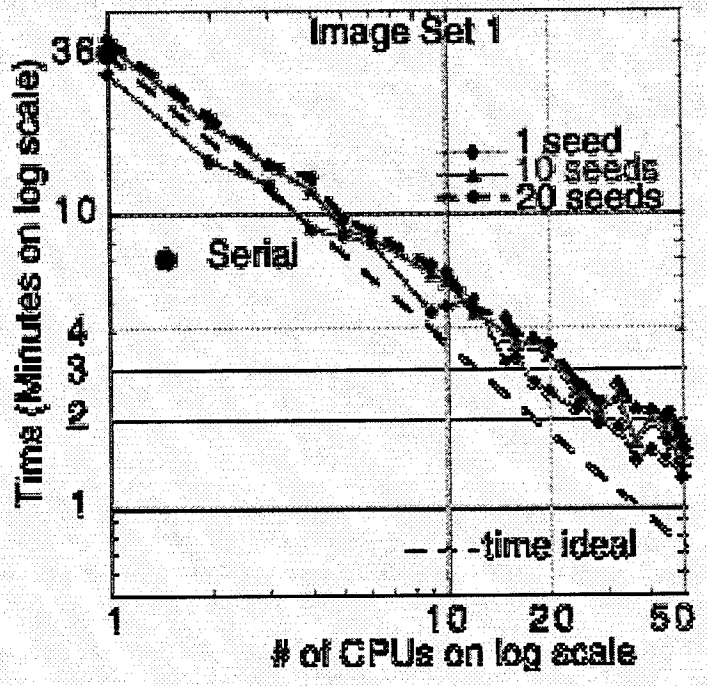
Problem

- Need ranging data,
  ->can deduce from relative shifts in left and right image
  ->correlation
- Not all pixels can be correlated (parallax or terrain similarities)
- Computationally intensive



Parallelization of Stereo Image Correlation





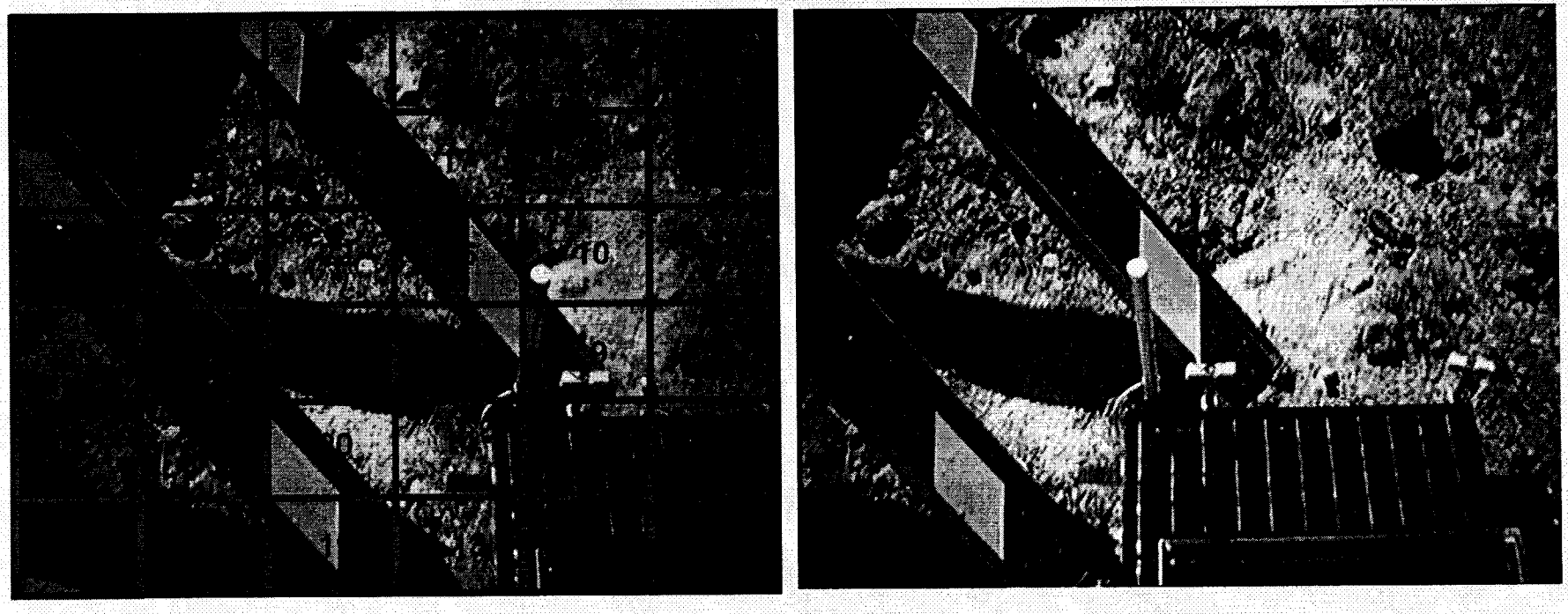
Timing Results

- **Original / 450 MHz: 65 minutes**
- **1 CPU / 800 MHz: 36 minutes**
- **20 CPUs / 800 MHz: 3 minutes**
- **50 CPUs / 800 MHz: <1.5 min.**

Impact:

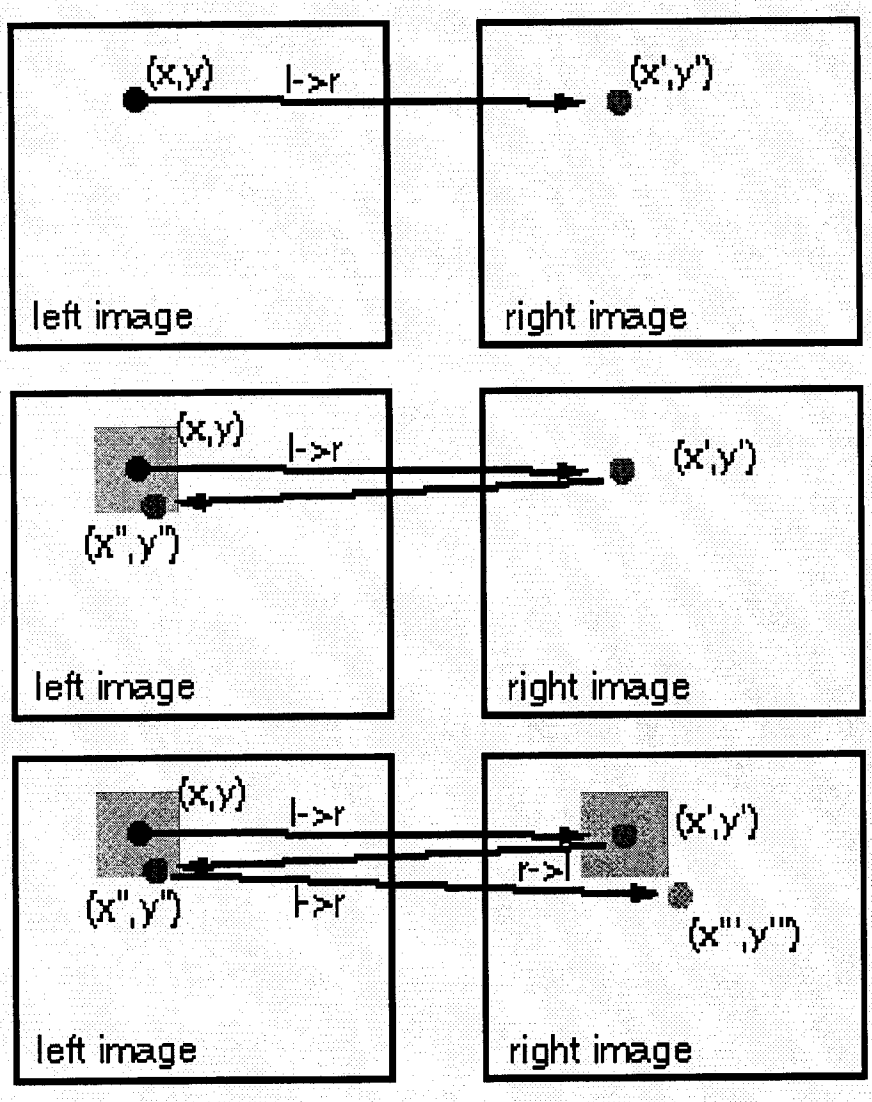
- **Near real-time correlation capabilities.**
- **Enable QUALITY CONTROL of the correlation**

Correlation Error Can Occur Unchecked!



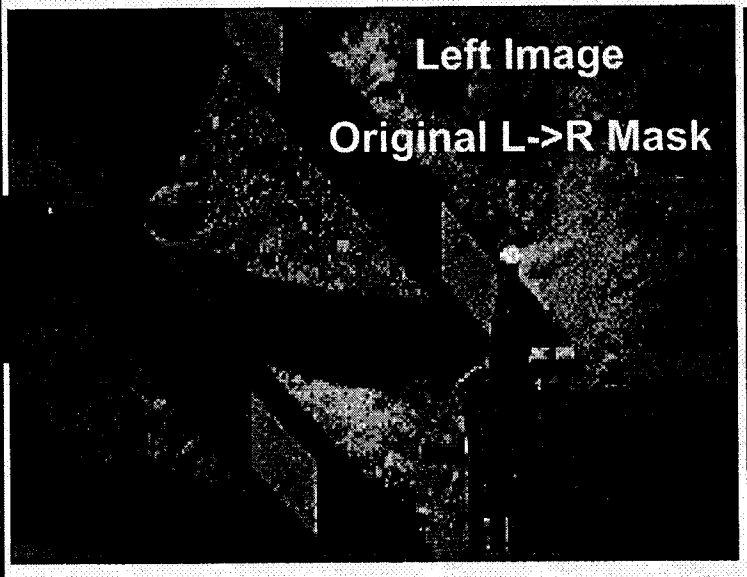
- CPUs 31-36 work on an area that does not exist in the right image
- Blue shaded pixels indicate successful correlation (from serial code)
  - segment 34 does not exist in right but was correlated -> ERROR

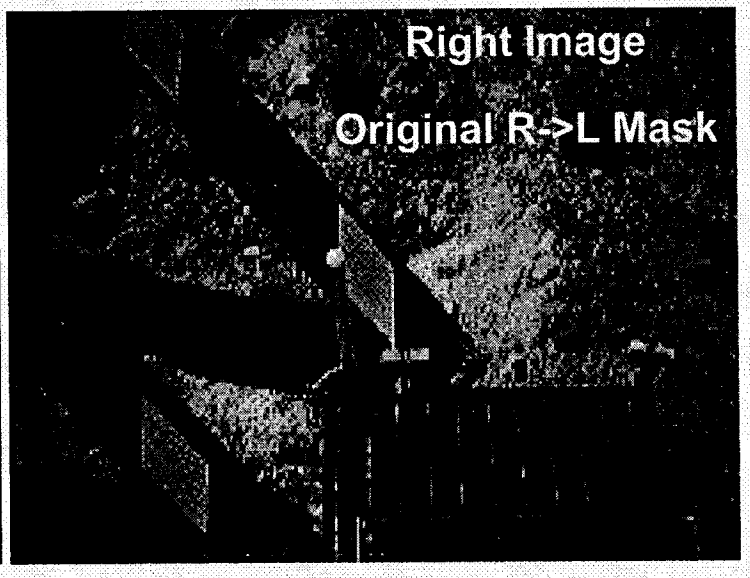
Image Correlation Quality Control Algorithm



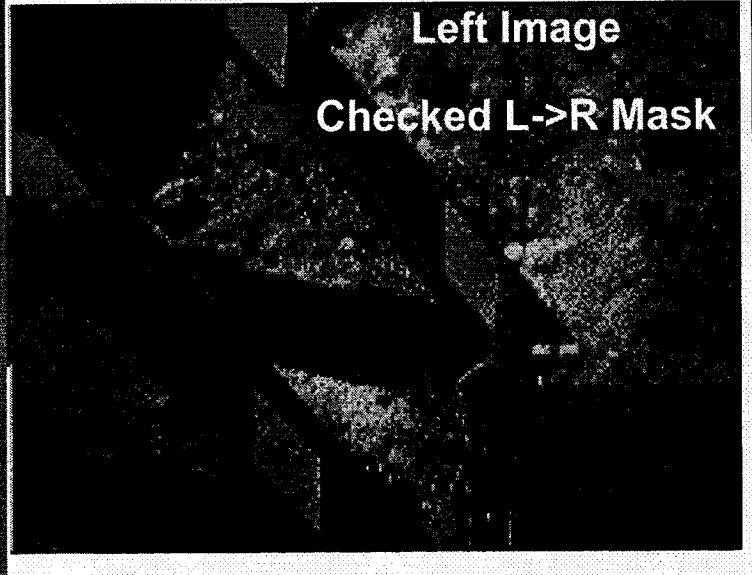
- Desired left->right mapping
- Using a right->left mapping, can we get back to the original point?
  - Double the work load!
  - Can allow for error (yellow window)
- Self-consistent check between left->right and right->left correlation.

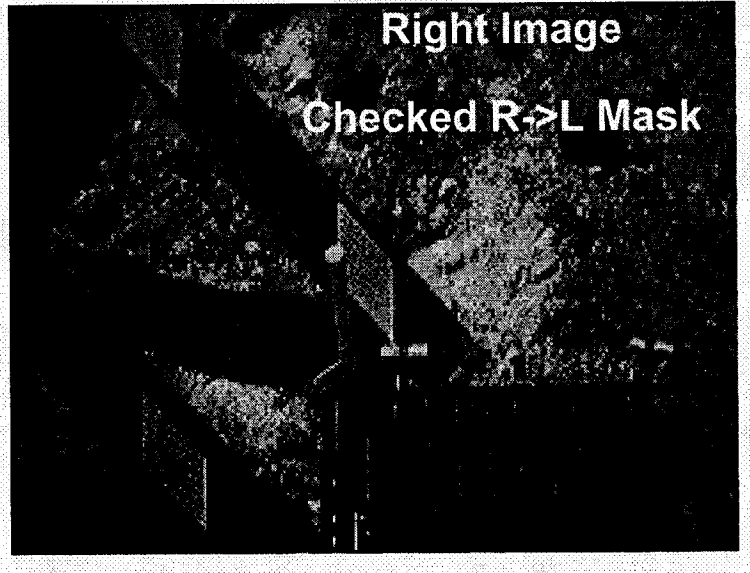
Quality Control Results





Masks before quality control

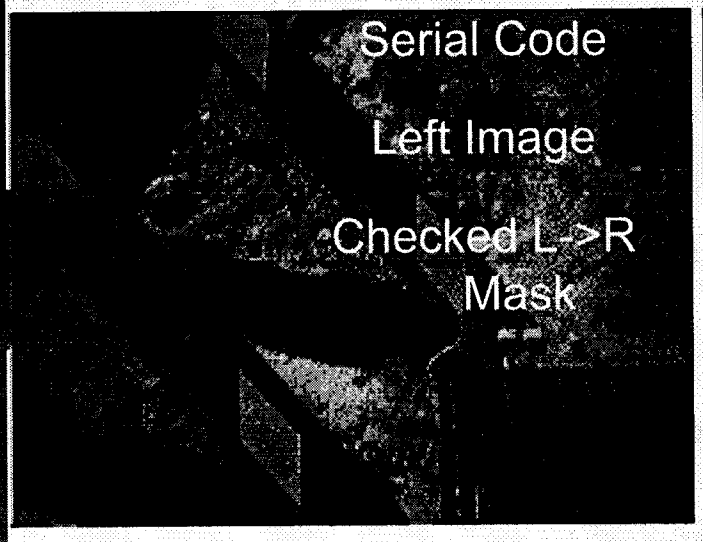


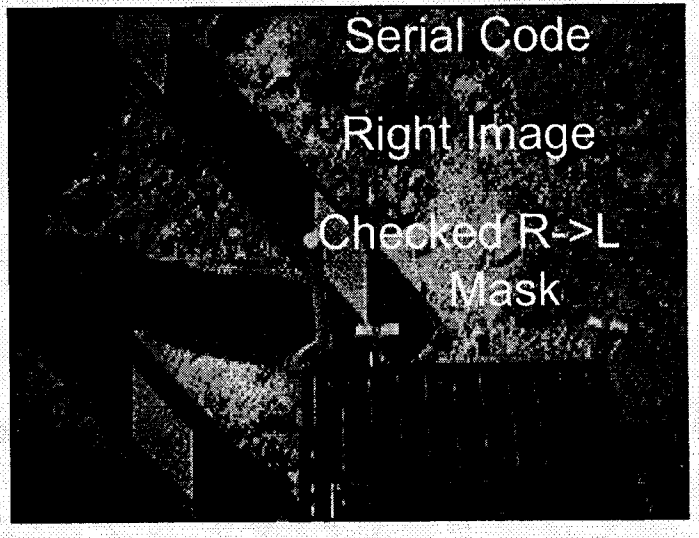


Masks after quality control

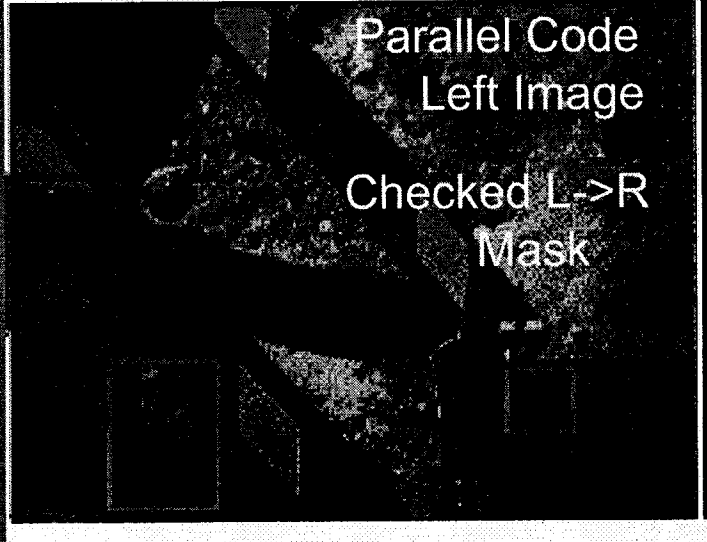
Spurious L->R and R->L correlation pixels can be ELIMINATED

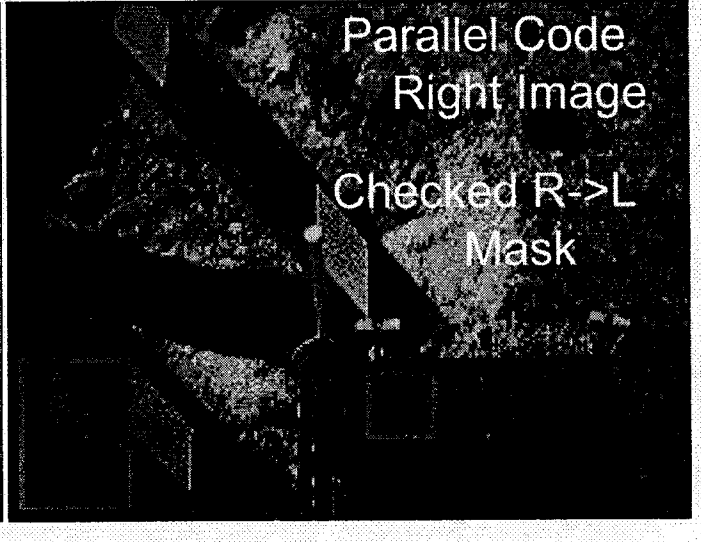
Parallel Correlation Gains Additional Areas!





Serial results





Parallel results:

- **Use many more seeds.**
- **Gain additional areas**
- **Checkerboard still a problem**

Mars Image Processing on Clusters

Problem

- Current technology requires about 90min per mosaic and each correlation pair.
- Requirements are 30 minutes

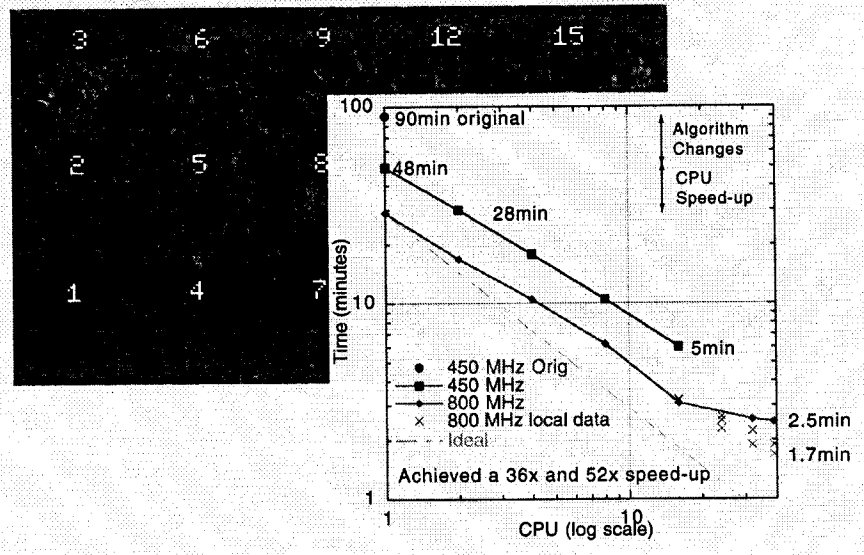
Provided Solution

- Parallelize on a commodity cluster
- Reduction mosaic time to < 3 minutes
- Reduction of correlation times to < 3 minutes
- Enable correlation quality control by running correlation twice and weeding out bad pixels

Impact

- Exceeded required time reduction
- Pixel correlation verification
- Correlator now has a forced completion, prior serial code could run indefinitely.

Mosaics from many images



Correlation of Stereo Pairs